

DOCUMENT RESUME

SE 061 236

ED 417 946

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TITLE Art as a Probe of Scientific Inquiry.
PUB DATE 1998-02-00
NOTE 22p.; Paper presented at the Annual Meeting of the Consultation of the International Consortium for Research in Science and Mathematics Education (7th, Trinidad, February 26-28, 1998).
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Concept Formation; Educational Change; Elementary Education; Higher Education; Inquiry; *Methods Courses; *Preservice Teacher Education; *Science Education; *Scientific Methodology; *State Standards; Teacher Education
IDENTIFIERS Texas

ABSTRACT

This study investigates the development of an understanding of scientific inquiry by preservice teachers as a result of their participation in a five-week elementary science methods class. The study was done in response to changes in state standards for teacher education in Texas and focuses on the effectiveness of a one-hour methods course in science on inquiry. Data collected by way of the final examination suggest that students in this course develop an understanding of scientific inquiry. Further investigation via a free written response to a particular work of art involving methods students (N=115) provided results demonstrating that even a short-term exposure to a science methods class can result in a change in vocabulary. These changes are compatible with an inquiry approach to elementary science teaching. Contains 2 appendices and 3 data tables. (DDR)

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Art as a Probe of Scientific Inquiry

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The purpose of the proposed study is to investigate the development of an understanding of scientific inquiry by preservice teachers as the result of their participation in a five-week elementary science methods class. With the adoption of the 1989 Standards for Teacher Education, Schools of Education in Texas were limited to 18 hours for the preparation of future teachers. The University of Houston-Clear Lake decided to meet this limitation by implementing one-hour methods courses in science, mathematics, and social studies. Since the adoption of this new course structure, the overriding focus of the science course has been on inquiry. Data collected by way of the final examination (based upon a standardized instrument) suggest that students are developing an understanding of scientific inquiry. These data are biased (1) because they were not collected for a research purpose and controlling for outside influences, and (2) because the instrument used is the course exam and, thus, students are predisposed to give a response that they believe is expected by the instructor.

Recently, the Principal Investigator discovered a painting at the Hirshhorn Museum in Washington, DC (see Appendix A). This picture seemed to capture the essence of the inquiry approach for elementary children. Based upon that picture, an idea was generated to use free written response to art as a probe of the students' developing understanding of inquiry.

Presented at the 7th Consultation of the International Consortium for Research in
Science and Mathematics Education, Trinidad, West Indies, February 26-28, 1998

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The purpose of this study is to determine if students change in their understanding of scientific inquiry as a result of their participation in a 5-week elementary science methods class. As a probe of their inquiry knowledge, the students were asked to respond to a piece of art, "Will Wonders Never Cease," by Jess.

It is hypothesized that the preservice teachers' descriptions of this piece of art will more fully reflect the lexicon (vocabulary) associated with inquiry science teaching following their participation in the five-week science methods course as compared to their response to the art at the beginning of the course.

One hundred-fifteen students enrolled in three sections of elementary science methods participated in the study. At the beginning of the first day of class (even before any course introductions were made) and at the end of the fourth day of class (it was decided not to administer the post-assessment on the fifth day so as not to confuse this activity with the final exam), students were shown the picture for 5 minutes and asked to respond in three ways: (1) list ten words that come to mind when viewing the picture, (2) propose a title for the picture, and (3) develop a word map to link the 10 words (See Appendix B).

A comprehensive list of all words given pre and post-assessment was generated and consisted of 473 unique words. This list was given to fifteen science educators who determined which words were associated with the lexicon of inquiry-based science (See Table 1). It was determined that at least three-quarters of the reviewers had to list this word as associated with scientific inquiry to be considered an "inquiry word." Based upon this list, the frequency distributions of inquiry versus non-inquiry words for the pre-assessment and post-assessment were compared using a contingency table and Chi-

square analysis (See Table 2). It was found that there was a significant gain in students use of inquiry-oriented vocabulary to describe the painting after participating in 12 hours of elementary methods class experiences.

This study demonstrates that even a short-term exposure to elementary methods is capable of producing behavioral changes in preservice teachers as the linguistic level which are more compatible with an inquiry approach to elementary science teaching.

There were two additional outcomes of this study that became apparent during the data analyses. The first was the relative lack of uniformity of responses of those science education experts who were asked to identify words that they associate with science inquiry (See Table 1). Of this list of words generated by the students to describe the picture, 249 of these words were listed by at least two of the science education reviewers as "associated with scientific inquiry." However, there were only 38 words for which there was agreement by at least three-quarters of the reviewers that they were associated with scientific inquiry. This suggests that although the notion of science inquiry is central to our discipline and a central theme in the *National Science Education Standards*, there does not appear to be a uniform definition of what constitutes scientific inquiry.

A second benefit is the opportunity to examine the outcomes of the science methods course from a microperspective. Table 3 shows the change in responses at the beginning of the course to the end of the course for the words most associated with scientific inquiry. For eleven of the words, there is an increase in responses of 3 or more respondents. Most of these words would be associated with a process approach to science (exploration, observing, questioning, inquiry, investigating), which was a

significant focus of the 5-week course (See Appendix C for the course syllabus). It is interesting that there is a decline in one word (explore) but more than a doubling of the active form of the word (exploring).

Equally interesting are those areas in which there was no change. Of particular note are "discovering" and "discover", "experimenting", "seeking", and "experiencing." There was a slight decline in one word (imagination). It appears that the strong emphasis on a process orientation may have been at the detriment of a focus on the human side of science education. This would certainly be an area for future investigation.

Conclusion

The use of an art probe appears to be a useful means for determining the science-related verbalizations of preservice teacher education students. From this study, it appears that even a short exposure to a science methods class can result in a change in vocabulary.

Table 1

Words Associated with the Lexicon of Scientific Inquiry

100%	inference	interaction	seeing
brainstorming	inferring	interested	success
discovering	scientific	learn	suspense
exploration		provoking	unknown
	69%	searching	31%
92%	classifying	sorting	anticipating
cooperation	evaluating		appealing
creative	examine		appropriate
curiosity	experience	46%	choices
discover	gathering	concentration	clever
experimenting	interesting	finding	collection
information	investigative	interest	creating
inquiring	knowledge	intrigue	enthraling
inquisitiveness	observing	intriguing	explorers
observation	questions	looking	feeling
questioning	reflection	natural	focus
seeking	researching	revealing	group
team work	scientist	sciences	intrigued
thinking		search	listening
	62%	smell	look
85%	captivating	sounds	outdoors
active	conclusion	teaching	relationships
analytical	cooperating	thought	satisfying
curious	cooperative	wonder	time
engaging	learning		touch
experiencing	science	38%	touching
experiments	senses	adventure	trying
explore	sensory	adventures	
exploring	sharing	adventurous	23%
imagination	studying	amazement	accomplishment
inquiry	wondering	careful	alive
inquisitive	wonderment	cautious	attention
investigate		concentrating	awe
investigating	54%	eagerness	birds
investigation	assessing	excited	blooming
involved	doing	exciting	blue skies
research	engaged	fascinated	busy
thoughtful	enjoying	focused	butterflies
	examining	nature	butterfly
77%	excitement	patience	captivated
discoveries	groups	puzzled	childlike
discovery	interacting	realistic	children

clouds
detailed
eager
enjoy
fascination
fish
flowers
fun
growing
hands
helping
historic
insects
intent
kids
leadership
life
magical
marine life
marsh
meadow
meadows
memorable
mushroom
mystery
naturalistic
ocean
open
plants
proportional
pure
recurring
rocks
salty
sealife
see
sky
teacher
together
water
waves
weather
wind
wonderful

15%
anxious
apprehensive
beauty
big
books
boy
bug
bugs
care
caring
cold
confusion
daring
daylight
delight
delighted
drawing
elementary
emotional
entertaining
field
future
gritty
heart-warming
historical
history
intense
knowledgeable
leader
light
lively
marshland
oil
outdoor
physical
pleasing
pond
precious
quiet
reaching
realizing
refined
refreshing
rough
sand

scary
seagull
seagulls
seashells
seashore
seaside
serious
shading
shells
small
soft
sun
surprise
timeless
togetherness
vibrant
warm
wildlife
windy
woman
youngsters
youth

8%
admiring
amused
Autumn
beach
beautiful
birth
blue
blurry
bonding
boys
breeze
bright
calm
calming
capture
captured
carefree
caught
century
cheerful
clapping
classic

clean
close
close-knit
close-up
closeness
colorful
colorless
colors
comforting
contemporary
cool
damp
dark
evening
expressive
Fall
family
fishing
float
flowery
flutter
fragrant
free-spirited
fresh
friendly
friends
friendship
frightened
fun-loving
gentle
girl
girls
giving
grass
grassy
green
happiness
happy
healthy
hopeful
inside
joy
lake
landscape
landscaped
large

laughter
life like
little
living
love
loving
memories
morning
moved
muted
naive
net
objects
old
old-fashioned
old-timers
outside
painted
painting
passive
past
pastel
pastels
peaceful
picking
plain
plaster
play
playful
playing
playmates

pleasant
pleased
pleasure
pretty
proud
relaxed
relaxing
relayed
seascape
serene
shaded
siblings
silent
sister
smile
smiling
solemn
Spring
Spring-like
Spring/Summer
springtime
Summer
sunny
sunshine
sweet
tender
textured
tranquil
tranquillity
trash
undivided

unity
waiting
warmth
wet
white
yellow
young

0%
1900s
afternoon
angelic
balmy
bland
brave
breezy
brother
brothers
canvas
catch
catching
childhood
clothes
country
cozy
dismal
dressed-up
dull
Easter
England
European

expressionist
free
free time
freedom
hurry-up
idyllic
innocence
innocent
kind
lazy
light hearted
mischievous
Monet-ish
money
netting
nice
peace
picture
reserved
sandy
sisters
sneaky
something
subdued
three
trusting
vacation
well-dressed
well-mannered
with
worn

Table 2
Chi Square Analysis

	Pre-Course	Post-Course
Inquiry Words	$f_o=100$ $f_e=135$	$f_o=181$ $f_e=146$
Non-Inquiry Words	$f_o=777$ $f_e=743$	$f_o=767$ $f_e=801$

1. H_0 = no difference among cells

2. H_a = difference among cells

3. α = 0.05

4. df = 1

5. $\chi^2_{(crit, 0.05)} = 3.84$

6. $\chi^2 = 20.46$

7. $\therefore$ Reject H_0

Table 3
Change in Word Use

Words	Pretest Tally of Responses	Posttest Tally of Responses
100%		
brainstorming	0	1
discovering	6	7
exploration	3	7
92%		
cooperation	1	6
creative	1	1
curiosity	19	20
discover	1	2
experimenting	1	2
information	0	2
inquiring	1	2
inquisitiveness	1	0
observation	0	3
questioning	1	5
seeking	1	1
team work	0	1
thinking	0	3
85%		
active	0	1
analytical	0	1
curious	23	27
engaging	0	3
experiencing	0	1
experiments	0	1
explore	3	0
exploring	10	26
imagination	2	0
inquiry	0	7
inquisitive	4	10
investigate	0	2
investigating	1	6
investigation	0	3
involved	0	2
research	0	1
thoughtful	0	1
77%		
discoveries	0	1
discovery	21	22
inference	0	1
inferring	0	1
scientific	0	1
TOTAL	100	181

Appendix A

Will Wonders Never Cease

Jess

Hirshhorn Museum and Sculpture Garden
86.5885

said he would go on with his collecting and that was all there was the
of discussing and this is a little bit of the story that happened
second it is very interesting.



Appendix B
Student Response Form

List 10 words that
you would give to
describe this picture

What title would you give to this picture?

What is your name
(used only to check
informed consent)

Make a map (using any mapping technique) of your 10 words to describe this picture

Appendix C
Course Syllabus

University of Houston Clear Lake
ELEM 4212: Science in the Elementary School

Spring 1997

Instructor:

Dr. Steven J. Rakow
1125 Bayou Building
283-3593
rakow@tenet.edu OR rakow@uhcl4.cl.uh.edu

Office Hours

Monday 9-11 or by appointment

Texts:

- Rakow, S.J. (1986). Teaching Science as Inquiry. Bloomington, IN: Phi Delta Kappa.
Rakow, S.J. & Brandhorst, T.R. (1989). Using Microcomputers for Teaching Science, Bloomington, IN:
Phi Delta Kappa.
Quick Copy materials

Objectives:

- To demonstrate an understanding of the nature of inquiry science by:**
- demonstrating an understanding of the definitions and concepts of inquiry science.
 - demonstrating an ability to revise existing science activities to use an inquiry model.
 - demonstrating lesson planning and classroom management skills which are consistent with an inquiry model.
 - completing assignments which demonstrate the ability to evaluate existing science curricula and activities for their appropriateness in a science classroom taught by an inquiry model.
- To view science in the elementary school as a basic by:**
- demonstrating an understanding of the historical and current status of elementary science curricula and instruction.
 - demonstrating an understanding of the relationship between science and other elementary school subject areas.

Methodology:

The course will utilize lectures by the instructor, readings, media, small group discussion, laboratory experiences, and other hands-on experiences to enable participants to effectively use the inquiry model for science teaching in the elementary school.

Course Evaluation:

The following will be used to determine your final grade.

Attendance and Participation	10 points
Textbook Adaptation Assignment	25 points
Methods Examination	50 points
Observation Assignments	15 points
Total	100 points

Grade Distribution

93-100	A	73-76	C
90-92	A-	70-72	C-
87-89	B+	67-69	D+
83-86	B	63-66	D
80-82	B-	60-62	D-
77-79	C+	<60	F

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Attendance and Participation

Because so much of the learning associated with this class takes place through hands-on activities during the class session, attendance at all class sessions will be required. You will earn 2 points for each complete class session that you attend. **No late arrivals, early departures, or absences will be excused, except with a physician's note. Roll will be called at the beginning of each class. It is your responsibility to sign in each week.**

Academic Honesty Policy

Academic honesty is the cornerstone of the academic integrity of the university. It is the foundation upon which the student builds personal integrity and establishes a standard of personal behavior. The University can best function and accomplish its mission in an atmosphere of the highest ethical standards. The University expects and encourages all students to contribute to such an atmosphere by observing all accepted principles of academic honesty. This policy is designed to encourage honest behavior and is jointly administered by faculty and students.

HONESTY CODE: The honesty Code is the university community's standard of honesty and is endorsed by all members of the University of Houston-Clear Lake academic community. It is an essential element of the University's academic credibility. It states:

I will be honest in all my academic activities and will not tolerate dishonesty.

American's With Disabilities Act

In accordance with Section 504 of the federal Rehabilitation Act of 1973 and Americans with Disabilities Act of 1990, the University of Houston-Clear Lake endeavors to make reasonable adjustments in its' policies, practices, services and facilities to ensure equal educational programs and activities. Whenever a special accommodation or auxiliary aid is necessary in order to ensure access to and full participation by students with disabilities in university programs and services, the department responsible for the program or service will work with Health and Disabled Services and appropriate federal and state agencies to ensure that reasonable accommodations are made. The student requiring special accommodations or auxiliary aids must make an application for such assistance through the Office of Health and Disabled Services (Room 1406 Bayou). Proof of disability from a competent authority will be required, as well as information regarding specific limitations for which accommodation is requested. **Should you need special accommodations, please contact me after class or during office hours.**

Textbook Adaptation Assignment

- You will be assigned to work with a group of students at a grade level of interest to you.
 - Select a science topic that would typically be taught at your assigned grade level. You may wish to consult adopted elementary science series for guidance.
 - Develop at least 3 hands-on, inquiry-oriented lessons that would support your topic. Strive to develop lessons that use easily obtained materials.
 - Develop these 3 lessons to follow the Five E Model:
 - Engagement
 - Exploration
 - Explanation
 - Elaboration
 - Evaluation
 - Using the format provided in class, develop these lessons to support science teaching at your assigned grade level.
 - Make sufficient copies for each person in your group and the instructor.
 - Include the attached cover sheet as your first page.
- Due during the class session of the FIFTH WEEK of class**
Late assignments not accepted.

Methods Examination

The methods examination will consist of 40 multiple-choice items and one essay over the material presented in class and over the assigned reading materials. **Sample questions will be given before test.**

Observation Assignment

You are required to complete the science observation assignments outlined in the observation manual. Your grade will be lowered if this form is incomplete or inaccurate, or late.

Due by 5:00 pm one week following your last scheduled observation. Activities may be turned in during class any time any time before that date. If turned in on after the class session, they must be submitted to my office.

Course Outline

Week One

Course Overview

Nature of Science Inquiry

The Nature of Science as a Process of Inquiry

Teaching Science as a Process of Inquiry

Learning Science as a Process of Inquiry

Science Teaching in Texas

The Evolution of a Process Approach

Essential Elements

Scope and Sequence

Week Two

The Science Process Skills

Observation

Classification

Communication

Measurement

Inference

Prediction

Relating Objects and Events

Week Three

The Science Process Skills, cont.

Operationally Defining

Experimenting

Planning for Inquiry Science

The Five E Model

Week Four

Assessment of Inquiry Science

Evaluation of Knowledge Domain

Evaluation of Science Skills

Evaluation of Science Attitudes

Alternative Assessment Procedures

Observation

Performance

Portfolio

Week Five

Resources for the Elementary Science Teacher

Programs: ESS, SCIS, GEMS, FOSS (SAVI/SELPH)

Sources of Science Supplies

Technology in the Classroom (including *Windows on Science* demo)

Professional Organizations: NSTA, STAT, MATS, TCES, etc

LEARNING CYCLE ACTIVITIES DUE

FINAL EXAMINATION

Name _____

Grade Level _____

ELEM 4212

Textbook Adaptation Assignment

For each textbook adaptation include:

	Possible Pts	Earned Pts
Title	1	_____
Objective	1	_____
Time	1	_____
Safety Considerations	1	_____
Essential Elements	2	_____
Materials	3	_____
Engagement	3	_____
Exploration	3	_____
Explanation	3	_____
Elaboration	3	_____
Evaluation	3	_____
Source	1	_____
Assignment Total	25	_____

(This rubric must be attached to your textbook assignment when submitted for a grade)